Internet of Things and Agriculture. Proximal sensoring and Grass8 system for a sustainable management of pastures

Internet of Things and Agriculture. Proximal sensoring and Grass8 system for a sustainable management of pastures.

Prof. Riccardo Beltramo, University of Torino
Interdipartimental Center on Natural risks in mountain and hill areas - NatRisk
Lo Scatol8 per la Sostenibilità srl

Abstract
The paper starts introducing management systems in economic organizations. It continues drawing a parallel between the consequences of policies for sustainability that have involved manufacturing companies and the evolution of agriculture, till the point of precision agriculture.

Mechanization and automatization of agriculture are considered as means that evolve thanks to the introduction of electronic and software innovations, and, today, with the connection to the Internet. From Things to Connected Things and the Internet of Things.

The concepts and implications of the IoT for agriculture are discussed through examples, useful for estimating the potential of the IoT

Scatol8 is introduced to approach the design of Grass8, an ongoing project oriented towards sustainable management of pastures will be showed.

In the conclusion, strong and weak points of IoT applications will be discussed.

1. Background: Open systems and MMSS

My experience has seldom met agriculture, it is related to economic organizations, that's to say to open systems, and its objectives are the optimization of performances through implementation of tailor made integrated management systems.

These are management tools developed at the dawn of the debate on sustainable development, which have undergone improvements to transfer the contents of the evolution that the concept of sustainable development has lived, since 1987.

The search for sustainability, considered in a broad sense, gave life to guide-lines, thousands books and more or less creative tools available today for economic organizations. There are many tools available for those companies who trust in the application of sustainability principle; we refer to methods that allow companies to witness their engagement in CSR, today buzzword for sustainability.

A non-exhaustive list, but one that certainly considers the most important tools is the following:
- Life Cycle Thinking: Life Cycle Assessment, Social Life Cycle Assessment, Life Cycle Costing
- EU Eco-label
- Environmental Management & Audit System & ISO14001
- ISO 50001 - Energy Management System
- ISO 26000 - Social Responsability
- ISO 45001 - Occupational health and safety
- Global Reporting Initiative
- CSR, Non Financial reporting

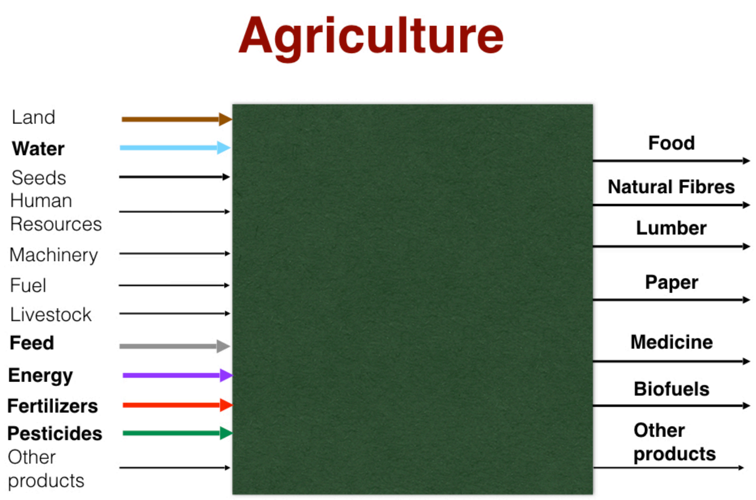
These tools highlight common elements:
- all consider transformation processes;
- all foresee a succession of phases for the development: for some it is about providing answers to checklists, filling inventory tables, for others to elaborate indicators or to design management systems.
- all need evidences, to build upon.

An unavoidable condition for determining whether or not operations (or processes) are sustainable, is the availability of accurate data.

Management systems can be integrated, by merging attention to sectors that plays different role in the sustainable management of a economic organization. Integrated systems help company to behave properly under ordinary, abnormal and emergency conditions.
This is the starting point: the integration of Quality, Environment and Safety management systems allows an economic organization to define KPI and keep them under control, applying self-defined behavioral rules which consider and marry the requirements of the company and of the laws, adopting voluntarily and adapting a framework established by ISO or other bodies.

The company's requirements are defined by the market. They deal with the ability to respond efficiently and effectively to customer and stakeholders demand. Law constraints depend on time and place where the company is located. More and more laws are inspired and directly derive from documents defined at international level by supranational organizations. They aim to ensure conditions of safety for the health of employees and, in general, of human beings, of environmental protection, of the conservation of resources. International agreements also provide for a commitment to define and guarantee fair and widespread development conditions.

2. Agriculture
The construction of an integrated management system in agriculture may start from the diagram in Fig. 1



The fundamental and urgent theme, often referred to in the Food and Agricultural Organisation (FAO) documents, that take us to the relation between agriculture and standardized management systems, is food security. A mono-thematic view, however, is weak: food security is a much broader and more ramified question, which draws nourishment from various fields of knowledge, which are combined to give life to a model of sustainable development.

FAO predicts that the global population will reach 8 billion people by 2025 and 9.6 billion people by 2050. In order to keep pace, food production must increase by 70 percent by 2050.

If we consider the space-time horizon in which we live, the regulatory framework is shaped by the Agenda 2030:

"This Agenda is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. We recognise that eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development. All countries and all stakeholders, acting in collaborative partnership, will implement this plan. We are resolved to free the human race from the tyranny of poverty and want and to heal and secure our planet. We are determined to take the bold and

transformative steps which are urgently needed to shift the world onto a sustainable and resilient path. As we embark on this collective journey, we pledge that no one will be left behind. The 17 Sustainable Development Goals and 169 targets which we are announcing today demonstrate the scale and ambition of this new universal Agenda."

Regarding the theme of this intervention, the most relevant objectives are:

- 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
- 3: Ensure healthy lives and promote well-being for all at all ages
- 6: Ensure availability and sustainable management of water and sanitation for all
- 7: Ensure access to affordable, reliable, sustainable and modern energy for all 8: Decent work and economic growth
- 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- 12: Ensure sustainable consumption and production patterns
- 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

However, it can be considered that other objectives also intersect the relations between agriculture and development. Eg.: 1-End poverty in all its forms everywhere; 4-Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all ; 11-Make cities and human settlements inclusive, safe, resilient and sustainable.

The 2030 Agenda formalizes objectives and operating procedures for the signatory countries, outlining useful programs and actions, also in virtue of objective 17: Partnership for the goals.

Reaching 17 goals is difficult in itself. But it is even more difficult if we reflect on the fact that interdependencies exist between the objectives, destined to "tangle" because of the actions that will be carried out to achieve the individual objectives.

Defeating hunger, and therefore acquiring food security, is a very complex topic. Interference is generated between technical, economic and political facts that are based on behavioral guidelines that are not always oriented in the same direction. The three areas called to act jointly are linked by relationships that determine contradictory behaviors with respect to the desire to achieve the declared goal. For instance, if a system of energy policies and economic incentives favors the start-up of energy crops, if the arable land is determined and not scalable, these will take away food crops. In short, from agricultural fields to photovoltaic fields. It will be possible to proceed towards Objective 7, but to the detriment of Objective 2.

A lower supply of products, at the same demand, leads to an increase in prices. The demand, however, is bound to increase (given the forecasts of population growth), so there is a well-founded fear that the increase in prices may be such as to further worsen the current situation.

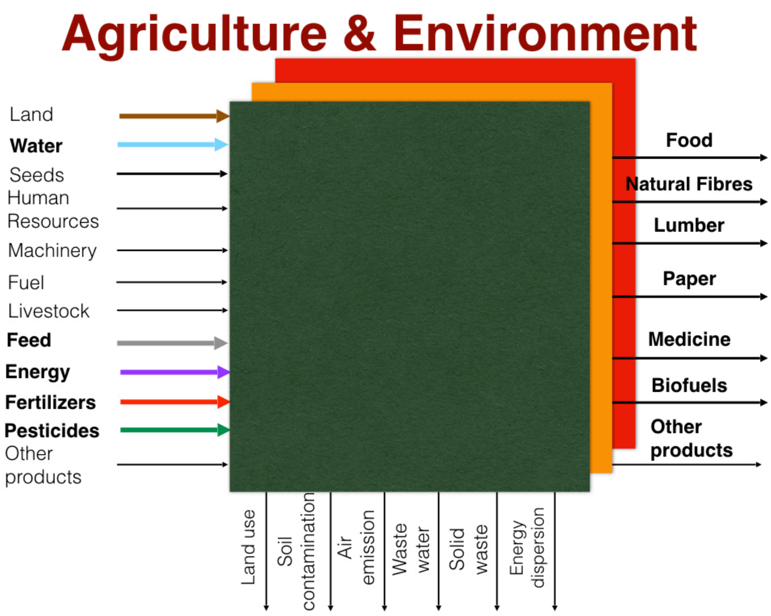
The starting point, for all entrepreneurs, is to optimize the use of resources with positive results, planning and systematically doing the operations at best, sniffing the market trends and introducing innovations to improve performance over time.

2.1 Precision agriculture

This process has gradually led to the transformation of management logics matured in the manufacturing industry to agriculture, to reach today the concept of precision agriculture.

"Precision agriculture" is a specification that leads an inexperienced observer to believe that before the addition of this complement agriculture was inaccurate. But perhaps we want to understand an agriculture which is managed bearing in mind that the resources available are not infinite, they are not infinitely renewable.

If we consider environmental consequences of traditional agriculture, it is confirmed that environmental conservation has not been yet the top priority.



Drivers:

- Environmental quality:
  - Land degradation
  - Water use: “Farming accounts for around 70% of water used in the world today and also contributes to water pollution from excess nutrients, pesticides and other pollutants. But the competition for water is increasing and the costs of water pollution can be high.“
  - Soil contamination
  - Air emission.
- Energy: Paradigm shift
- Nutrition - Diet shift: “*By 2050, global population is projected to be 50% larger than at present and global grain demand is projected to double. This doubling will result from a projected 2.4-fold increase in per capita real income and from dietary shifts towards a higher proportion of meat (much of it grain-fed) associated with higher income.*” [1]
- Conscious consumption: Food distribution involves the storage, processing, transport, packaging, and marketing of food. Food-chain infrastructure and storage technologies on farms can also affect the amount of food wasted in the distribution process. Poor transport infrastructure can increase the price of supplying water and fertilizer as well as the price of moving food to national and global markets. Around the world, few individuals or households are continuously self-reliant for food. This creates the need for a bartering, exchange, or cash economy to acquire food.
- Climate change: Climate change could increase annual precipitation and make more fresh water available in some places. Rising temperatures, however, could increase the rate of evaporation from surface waters and reservoirs and lead to the loss of freshwater held in glaciers. Furthermore, increased rainfall might come in the form of storms that lead to flooding and damage thereby doing more harm than good. Climate change poses a series of risks to water supply and water management systems, although much uncertainty remains.

Several innovations have been introduced in agriculture to improve productivity. They have not always been accompanied by attention to environmental, economic and social impacts.

The introduction of mechanization, first, and automation, after, had been possible thanks to activities that favored standardization: “production” (selection hybridization, etc.) of seeds with desired and steady characteristics, plant species with desired and constant characteristics, products with desired and constant characteristics. All this made it possible to considerably increase the quantity of production.

[1] Nature 418, 671-677 (8 August 2002) | doi:10.1038/nature01014, Agricultural sustainability and intensive production practices, David Tilman, Kenneth G. Cassman, Pamela A. Matson, Rosamond Naylor & Stephen Polasky

The increase in efficiency has occurred at the expense of diversity. The results were not negligible. For example, in the 1930s, the yields, in q / ha, of the so-called ancient grains were 20-25; the yields of the modern ones are 60-70. This happened thanks to precise processes of intervention on the seeds, to the improvement of crop alternations and cultivation techniques (plowing, harrowing, sowing, threshing and transport, fertilizer, seed, weeding, possible treatments)

Interventions such as these, lead us to consider the processes that occur in agriculture as well as those that occur in the manufacturing industry.

How to optimize the management of a company? In the industrial field, deterministic theories have emerged: subdivision of processes into elementary operations, assessment of the contribution of elementary operations to the overall result, possible improvement of the methods of execution or equipment used for elementary operations, verification of the effectiveness of change also in relation to the execution of the subsequent elementary operation.

In a manufacturing company, the ability to control the variables that affect efficiency and effectiveness is not complete, but greater than that of Agriculture, a primary sector. Both sectors want to govern the logic of production and may encounter difficulties in forecasting the demand, but the agricultural sector must be able to govern the variability of nature: the physical characteristics of the soil, the type and amount of rainfall, the effects of climate change are totally or only minimally manageable.

In agriculture, standardized solutions are applicable where there are standard situations: climate, plains, large extensions, production volumes, and the adequate amount of money. The size and capital requirements often led to economic and social consequences: mergers of companies, but also the disappearance of small and micro farms.

The effects of this approach are better understood if we consider the entire **production chain**. The acquired awareness on the generation of waste along the entire supply chain, has led the legislator to consider and discipline not only on the production stages, but the entire chain of transformation, transport, consumption and post-consumption. These phases, that contribute to the value chain, are greatly responsible for waste production. Optimization of the entire cycle is pursued, also through the prevention, valorization and reduction of waste.

The ultimate goal of Precision agriculture is **Circular agriculture**.
A mix of tradition and innovation to increase the efficiency thanks to waste valorization. New production chains are activated: pharmaceutical, nutraceutical, cosmetics recover precious substances from waste and transform them into profitable products.
The term “waste valorization” refers to any industrial processing activities aimed at reusing, recycling, or composting from waste, useful products, or sources of energy. It usually takes the form of one of the following activities: processing of residue or by-products into raw materials, use of discarded finished or semifinished products as raw materials or energy sources, use of waste materials in manufacturing process stages, and addition of waste materials to finished products.

The possibilities of exploitation of waste could increase considerably, if the corporate networks are configured and activated, following the principles of **industrial symbiosis**.

To sum up:
In Industry:
Determinism -> standardization = no variability -> raw materials std -> std components -> std production cycles -> std products

In Agriculture:
Determinism -> standardization = no variability -> std seeds -> std plants -> std food raw materials -> std production cycles -> std products

Standardization has proved successful for mass production, where competition is played on minimizing costs, achieved through a high volume of production. But as a result of increased well-being, consumers' wishes evolve and consumers become less satisfied by standardized solutions: every consumer feels unique and wants personalized products.

If industrialization looks for standardization, it is necessary to compare and balance this requirement with a new exigence, that of personalization. And here come into play the management theories that define the best rules for custom production (highly customizable) and mass, putting in the middle those of the make-to-order.

The industry has devised a production model to respond to this demand for uniqueness: lean manufacturing. In industry, the pervasive use of extremely sophisticated technologies, organizational techniques and intense training have allowed to innovate also in the creation of customized products, thus optimizing the logic of lean manufacturing. Unique products or in small batches, are realized and the time to market is drastically reduced, thanks to intelligent robotic systems, that manage warehouses, operations and transport.

This trend has also reverberated in the food industry which, starting from steady raw materials (controlled variability), invents products that respond to specific needs (quantity of product per package, precooked, frozen, etc ...) to meet the many and changing needs of the market. Even in the food industry, the content in terms of service tends to prevail over the intrinsic qualities of the product.

A competitive advantage is acquired and strengthened only if consumers' wishes are known and if the company is able to satisfy them before competitors.

Knowledge of the market is an element to keep in mind, when we consider the potential of IoT.

To make the point:
1 - all human activities need material and energy resources;
2 - the ways in which resources are used in the transformation processes affect the conditions of sustainability of development;
3 - sustainable development conditions can only be assessed if data are available;
4 - some data can be measured using measuring instruments (others through interviews, others from financial statements);
5 - the industrial sector has developed organizational and management models to incorporate data, maintain - and possibly improve over time - its economic, environmental and social results;
6 - network of enterprises can increase the efficiency, applying the principles of industrial ecology;
7 - agriculture is called to make this transition to improve efficiency and effectiveness, to respect the Planet and to fight starvation,

How? The itinerary develops in three steps.

A. Things
B. Connected things
C. IoT

3. The transition from Things to Internet of Things (IoT)

3.1 THINGS

Let’s consider the tractor: it is a means of transport, and it is also a versatile tool: it can perform various agricultural tasks, being easy to mate with various specific tools.

If these activities form the core of the tractor-thing, other features make up the tractor-service: tools for the detection of operating parameters, air-conditioned cabins, devices for maintenance scheduling, etc ...

The pervasive presence of electronic devices in vehicles, made possible by the miniaturization of the components and costs lowering, has determined a massive presence of sensors. The introduction of sensors in vehicles has greatly amplified the range of information that can be collected and transformed into service. This has happened also in tractors.

The expansion of sensors in the field of motor vehicles has determined a trajectory that, at a certain point, has intersected that of tractors and, more in general, of the means for agriculture.

The sensors monitor vehicle fluids, components and equipment to suggest maintenance or warn in the event of malfunctions, but they may go further, for example to plan the route to be used in carrying out agricultural operations. All this apparatus makes the tractor a "Thing" for our purposes.

If the tractor is a classic example, in agriculture the Remote Control Vehicles see the significant presence of drones. These are used for monitoring activities and timely intervention. "Seeing" the conditions of a field with a speed greater than that to which a farmer could proceed is useful, but it can not be all. Only if just as much speed and precision can characterize the intervention phase, then the increase in effectiveness and efficiency becomes real.

3.2 CONNECTED THINGS

A "thing" can “talk” with other things, assembled with micro-controllers, sensors and actuators, through various communication systems, and determine the creation of a local network. On the market you can find standardized solutions, proprietary technologies, with multiple features that are routed in a path of precision farming.

3.3 IoT

If these "Things" or networks of Things are able to connect to the Internet, access is gained to the privileges deriving from the presence in the Internet of Things. Things that collect, transmit, process and visualize data according to various objectives.

By Goldman Sachs, *“The Internet of Things, or IoT, is emerging as the next technology mega-trend, with repercussions across the business spectrum. By connecting to the Internet billions of everyday devices … the IoT merges the physical and online worlds, opening up a host of new opportunities and challenges for companies, governments and consumers.”*

Internet of Things (IoT) *“considers pervasive presence in the environment of a variety of things/objects that through wireless and wired connections and unique addressing schemes are able to interact with each other and cooperate with other things/objects to create new applications/services and reach common goals.”*

The Internet & Television Association - NCTA estimates that the number of connected devices will exceed 50 billion by 2020.

By International Telecommunication Union, the network architecture of IoT consists of the sensing layer, the access layer, the network layer, the middleware layer and application layers (Xian-Yi Chen, Zhi-Gang Jin, 2012; Tabassum Ara, Pritam Gajkumar Shah and M. Prabhakar, 2016):

- **Sensing layer**: the main features of this layer are to capture the interest information large-scaly by various types of sensors, identify intelligently, and share the captured information in the related units in the network.
- **Access layer**: this layer's main function is to transfer information from the sensing layer to the network layer through existing mobile networks, wireless networks, wireless LANs, satellite networks and other infrastructure.
- **Network layer**: this layer's main function is to integrate the information resources of the network into a large intelligence network with the Internet platform, and establish an efficient and reliable infrastructure platform for upper-class service management and large-scale industry applications.
- **Middleware layer**: this layer's main function is to management and control network information real-time, as well as providing a good user interface for upper layer application. It includes various business support platform, management platform, information processing platform, and intelligent computing platform.
- **Application layer**: this layer's main function is to integrate the function of the bottom system, and build the practical application of various industries, such as smart grids, smart logistics, intelligent transportation, precision agriculture, disaster monitoring and distance medical care. Industries 4.0 and Fourth Industrial Revolution

Such an amount of connected devices feeds the cloud with an unimaginable flow of data, giving rise to the Big Data phenomenon.

Big Data is often associated with what seems to announce the fourth industrial revolution: the Industrie 4.0 project. Promoted in 2010 by Germany. Industrie 4.0 is an industrial key -project in the high-tech strategy of the German government, which strongly has involved the professional industrial federations. The project intends to develop a new organization in Production that involves the whole value chain, after the first three industrial revolutions, marked by mechanization, electricity and information technology.
The introduction of the IoT and the CPS into the factory (Cyber-Physical Systems) acts as a catalyst for the fourth.
Six are the guidelines of the factory 4.0 [Kurt Salmon, 2015]:

- The factory is fully represented in a 3D simulation model for monitor processes, products and the production environment;
- Systems have the ability to interact and communicate with each other;
- Decisions are decentralized and the CPS can take decisions independently;
- Data analysis and decision making take place in real time;
- The factory is service-oriented, extending the IoT also to services;
- It is modular, adapting quickly to changes in the application. [2]

The key-point of the approach is the intercommunication between all the actors and the objects connected parties involved in the production line.

4. IoT and Agriculture

IoT makes it possible to integrate the data collected by the vehicle in motion with other data existing on the Internet, loaded by different subjects, with different purposes, but made available allowing unrestricted access and unrestricted reuse (Open Access).

It is possible to plan and monitor the progress of the activities, track the route taken by the vehicle, measure the time spent, fuel consumption, track the products administered and georefer to them and send them to a server on the Internet.

Since it is possible to find an economic value on most fo these data, they are useful for the preparation of financial statements and automatically filling in the exercise books.

Maintenance, component supply, appointment, parts replacement: it is possible to monitor the warehouse and proceed automatically with the order of products from suppliers. But also to sending information to the supplier and schedule delivery times and methods, and connect to similar systems, installed in companies belonging to the same network.

The programming of the activities can be performed considering exogenous and endogenous variables, for example the weather forecast.

This evolution has already be converted into marketed solutions, that makes precision farming real.

4.1 Literature review

John Deere is using the IoT to connect each of its vehicles to a mobile online platform called JDLink, which gives farmers and their dealers remote access to see location, utilization and diagnostic data for each machine.

Its John Deere Operations Center offers comprehensive IoT solutions for farmers, including wireless data streaming of production data, mobile monitoring, and weather and crop reporting in real time.

---

[2] R. BELTRAMO, S. MARGARITA, “Smart technologies per la gestione ambientale e paesaggistica: lo SCATOL8® della sostenibilità”, Atti del Congresso Nazionale AICA, Torino, 15-17 novembre 2011

Networked sensors and both historical and real-time data on weather, soil conditions and crop status help farmers enhance the value of their operations by ensuring equipment is operating reliably. They optimize each job by ensuring that crops are planted and harvested when and how they will produce the best yields, and achieving what John Deere calls “agronomic optimization” by engaging the trusted partners of the farmer to analyze data and recommend changes for future crop years. [3]

Not only new machines from John Deere can plow, sow and reap, but also collect a Farmer’s Almanac worth of data, including air and soil temperatures, moisture, wind speed, humidity, solar radiation and rainfall.
Smart watering systems sprinkle just enough water on the fields, in just the right places, and can detect leaks in water pipes—vital in dry and drought-affected regions like California (Alec Scott).

Precision Livestock Farming
Precision Livestock Farming is a subset of smart farming. Sensors are used for monitoring and early detection of reproduction events and health disorders in animals.
Typical monitored data are the body temperature, the animal activity, tissues resistivity, pulse and GPS position. SMS alerts can be sent to the breeder based on predefined events (Federico Guerrini, 2015).

Forestry management system
In the forestry, ”RFID can bring value by tracking timber through the whole logging operation, through shipment, monitoring for deliveries and such." In pilots and deployments worldwide, governments, research institutes, forestry and sawmill companies, and wood products manufacturers are employing RFID to optimize forest production and improve the quality of wood products, as well as to minimize environmental damage and enable companies to comply with U.S. and European rules barring import of illegal or endangered timber products.
But before RFID-tagging becomes common practice in the forestry industry, tag prices must come down and more solid business cases must be demonstrated. Meanwhile, RFID shows promise as a tool to help control wildfires.

Aquaculture management system
The first pilot of the IoT aquaculture management system is being tested on an eel farm in Gochang, South Korea. A set of sensors in dozens of 20-foot-wide eel tanks wirelessly transmit data on water temperature, pH and dissolved oxygen levels to a sensor hub, which in turn connects to SK Telecom’s LTE network using a machine-to-machine radio.

All these examples are proprietary solutions are tied to specific vendors and are expensive, closed and scarcely customizable.

To react this situation, a great deal of start ups were born. Some of them provides complete solutions, ready to use.

Libelium has developed a galaxy of application-oriented kits, which have been used by startups in order to improve management conditions in several fields:
- Smart irrigation systems
- Monitoring systems for Cocoa fields
- Monitoring systems fo Strawberries crops
- Monitoring greenhouse conditions to develop new products in the food industry
- Monitoring Horses and Equine Facility Management
- Preventing environmental impact in wastewater irrigation area

[3] IoT Case Studies: Companies Leading the Connected Economy,Part 2 in a Series Foreword by: Robert S Schimek, Executive Vice President and CEO, AIG Commercial
https://www.aig.de/content/dam/aig/emea/germany/documents/brochure/iot-case-studies-companies-leading-the-connected-economy-digital-report.pdf

Innovation marks the proposal of the company, which is stimulated by the request of potential users. Recently, it has been developed and sold a new Smart Agriculture Xtreme Sensor Node which provides maximum accuracy for crop monitoring.

The next step is to build vehicles equipped with automatic driving systems, avoiding stress and fatigue of a human driver and increasing the number of working hours. An evolution of the Remote control vehicles, that have been developed for spatial research and military missions.

It is not tomorrow, it is today!

https://www.youtube.com/watch?v=i8yChqU4mBE

Probably an autopilot capable of considering and linking together many parameters at the same time can lead the vehicle optimally, in relation to the work it will have to perform and the environmental conditions in which it will operate.

If we leave the tractor and consider the field, the sensors can be combined and connected to create networks with variable capillarity to collect data.

In relation to the variables detected, the data can be processed with appropriate algorithms to improve management -> Forecasting, RNA, Fuzzy, Simulation models.

Agricultural vehicles can carry out operations without a driver. They can work for different times and conditions, interacting with the variables detected by the sensors in the field.
The interaction between sensors in the field and satellite data, present on the Internet, with data related to the operating conditions of the agricultural vehicle, processed by software, allow the carrying out of automatic processing, being energy the main constraint.

Sensors for soil moisture detection and weather forecast data can be processed to decide if, when and for how long to activate an irrigation system. This can be done remotely, even without the intervention of an operator (M2M), if the software combines the data of a forecast model with those of the network, in order to send a signal to the actuators.

Working in Abnormal and Emergency Conditions
In the introduction, we stated that management systems deal with defining behavioral rules suitable for running the business in ordinary, abnormal and emergency conditions.

Further on, we approached the agricultural sector and mentioned the limited ability to predict and contrast the natural phenomena that affect production results.

There is, in fact, another important chapter for agriculture, that of prediction and intervention in emergency conditions:
- floods;
- fires;
- earthquakes;

- landslides
- avalanches.

All of them are phenomena capable of structurally influencing the conditions of a farm. In fact, the effects of these phenomena influence agricultural activity in the short and medium term.

These phenomena often cause real natural disasters whose magnitude is measured, in the short term, in victims and damages to the ecosystem and to human, civil and productive settlements. The restoration to the initial conditions can take years.

Although the attention devoted to forecasting and managing the effects of these phenomena has increased over time, and investments in parallel, the achievements recorded have been few and show that the spaces for improvement exist, and are wide.

If the operation of a remote sensing network in the agricultural field, under normal operating conditions, determines additional needs with respect to the industrial context (electrical supply of devices in isolated sites, data transmission, ...), in emergency conditions the elements to consider are greater because the event itself could seriously alter the operating conditions. To be sure that the system works in severe conditions, redundancy of power supply, data processing and transmission systems is required.

Various actors are called to intervene in emergency conditions. Collected data must be translated into operational instructions for a coordinated intervention and sent to the right subjects, in the communication code most suited to them.

4.2 Limits - critical considerations

We presented some examples of current and future IoT applications to agriculture. Is everything so easily accessible? Who can afford them?

Proprietary solutions are so costly that are restricted to wealthy farmers, to big companies who work large agricultural surfaces. By Eurostat, the largest average size of agricultural holdings in any of the EU Member States in 2013 was the 133 hectares recorded for the Czech Republic, with the second highest average recorded in the United Kingdom at 94 hectares. Six Member States reported average sizes below 10.0 hectares, with the smallest averages in Romania, Cyprus and Malta.

Will IoT able to improve living conditions for small and micro enterprises?

IoT seems like a magic word, pronounced which you immediately get all the answers to every management problem, to improve efficiency and effectiveness of all economic sectors.

The growth expectations of the number of devices connected to the network reinforce this conviction. Those who have lived through the information technology revolution and today work in the field of IoTs, perceive that it is a phenomenon of even greater scope. Perhaps the predictions are influenced by the typical enthusiasm of a start-up phase, they are quite different from source to source, but all converge on relevant numbers. And since the numbers involved in the order of magnitude of the billions, even the differences are of this order.

The attractiveness of IoT has increased, thanks to the production of Open source microcontrollers. Arduino and Raspberry are the best known. They were very prolific microcontrollers, from 2005 to today they have given life to many models, with increasingly advanced features.
Not only are they products, but also communities of makers and of enterprises that develop innovative solutions for agriculture, accessible and easy to implement.

Fascinating elements, also reinforcing, are the (apparently) low barriers to entry:

- Cheap prices of electronics components;
- Empirism - Makers & Hackers;

- Newsgroups: Massive amount of information available for those facing neophytes;
- Educations on Hardware & Software, tutorials;
- Kits;
- Success stories.

The micro-controllers have conquered the market, have met the needs of millions of fans of electronics and information technology because, along with them, there are low-price sensors and actuators on the market. Their combination makes it possible to realize circuits in a really easy way.

After the first enthusiasm, it turns out that the steps from the home experiment to prototyping and the industrialization of objects which constitute the network and software or, better, software that makes it functional to the objectives, require structured knowledge. The design and implementation of the elements that will be connected in the network require the collaboration of different professionals: engineers and informatics, but above all agronomists to define the rules that determine the intelligence of the system.

The product must be reliable, in all operating conditions, mechanically robust and waterproof to withstand bad weather and bumps: industrial designers, engineers and technologists are called to contribute. The system must be accessible, easy to install, plug'n play configuration, and to use: that’s a task for informatics engineers and communicators.

It has been noted that monitoring environmental factors is not enough and complete solution to improve the yield of the crops, as there are number of other factors that affect the productivity to great extent: attack of insects and pests which can be controlled by spraying the crop with proper insecticide and pesticides; attack of wild animals and birds when the crop grows up; possibility of thefts when crop is at the stage of harvesting. In order to provide solutions to all such problems, it is necessary to develop integrated system which will take care of all factors affecting the productivity in every stages like; cultivation, harvesting and post harvesting storage (Nikesh Gondchawar, Prof. Dr. R. S. Kawitkar, 2016).

A first solution has been envisaged since 2011, by Lance Donny, the CEO and founder of OnFarm. She identified a unique opportunity to leverage his extensive personal agricultural knowledge with connected applications to create and deliver a transformational suite of Internet of Things-based agricultural management services. On Farm delivers easy-to-use, smart, connected product applications that provide its customers with the ability to have a real-time big picture of the large and varying data points necessary for them to create optimal agricultural working and growing conditions.

If the numerical dimension of the objects that will connect to the Internet is difficult to imagine, it is even more difficult to have a perception of the amount of data that objects could bring together. The Walmart case is particularly significant, both because it illustrates well the meaning of the word Big in the expression Big Data. Wal-Mart Stores, Inc. (Walmart) is an American large-scale retail company in 1962, which has reached such a size that it has been in the past for several years position for turnover in the Fortune Global 500 ranking. From the Walmart Annual Report 2016 [Walmart, 2016] you can get some indicators that illustrate reality of the company: it employs 2.3 million people, with a turnover (2016) of 482 billion dollars, more than 11,500 stores in 28 countries and 260 million customers. It is believed that Walmart is cited more than 300,000 times per week in social networks, and that has complete data on 150 million American citizens. Furthermore, the systems of analysis (analytics) of Walmart, which cover millions of products and hundreds of millions of consumers, analyze 100 million keywords every day to optimize their use in the purchase of advertising. In 2014, Walmart claimed to handle around 30 petabytes of information on the purchases of its customers (a petabyte is a million billion bytes).[4]

The high number of data is a necessary but not sufficient condition for the verification of sustainability. Significant indicators must be identified and incorporated into management systems. We need logics that verify the conditions of sustainability, measure the level of achievement of the objectives, the deviations. The system must monitor a single company as well

[4] R. BELTRAMO, S. MARGARITA, op.cit.

as the whole supply chain. A simulation program written to develop alternative scenarios, respecting physical and economic constraints, must be instructed on the basis of appropriate instructions, to propose valid alternatives. We enter the field of artificial intelligence or the ability that the object or the network of objects takes in defining the most appropriate rules of behavior autonomously, depending on the circumstances. The construction of performing ANN Artificial Neural Networks is facilitated by the availability of many data, but the learning process must be oriented, and the ability of the network to recognize and act appropriately, given certain patterns, supervised.

5. Scatol8®

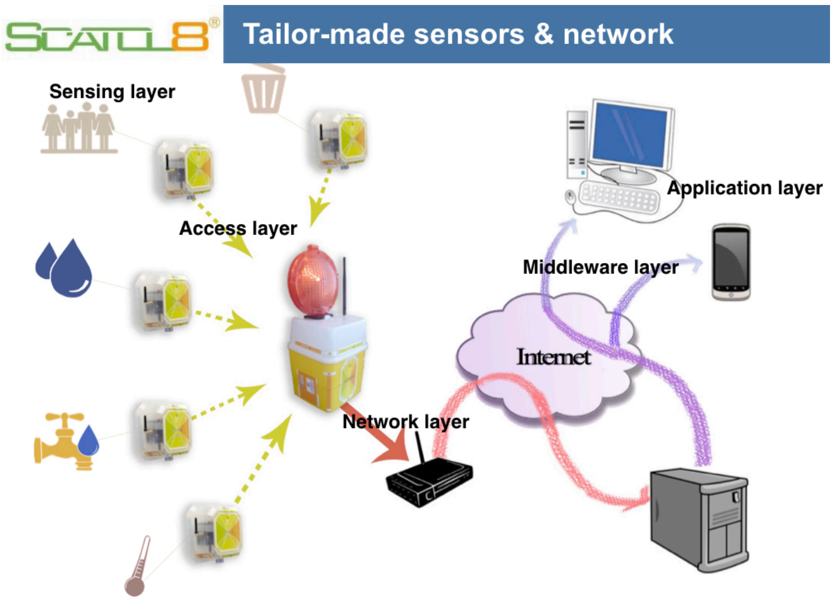
Scatol8® is a system designed to arouse awareness on the theme of sustainable development. Its mission: Spreading the culture of Sustainable Development. Its vision: To Each His Own Scatol8®

The idea sprung out on 2010, and after several experiences, it has become an academic spin-off company of the University of Torino, innovative start up of Regione Piemonte.

Scatol8® system is composed of :

- a team of people (People First !)
- a Wireless Sensors Network (WSN) to detect environmental variables, regarding relations between an organization and the environment ;
- a Crusc8 (a dashboard) for displaying instantaneous intensity and the time series of the values of each variable;
- the e-book "Scatol8®: A Path To Sustainability", which contains "recipes" for the construction and use of the system.

Sensors measures environmental and landscape variables (i.e.: energy consumption, water consumption, air quality, water quality, humidity, temperature, amount of waste, images) and transmits them to a personal computer on which they are stored, processed and displayed via an interface, the Crusc8 (dashboard). It can thus realize a real-time monitoring of each variable detected, in addition to evaluation of trend, thanks to the display of time series.
In turn, the personal computer merges its data on a server on the Internet that collects and organizes them in a collective database. In this way, they are published and accessible information on PCs, Smart phones, but also on relevant configurations for management purposes (production lines, departments, etc …).



Guidelines of Scatol8®

Designed in the perspective of sustainability, Scatol8® is inspired in its creation and implementation to various criteria, such as:

- Accessibility. Hardware and software are fully based on open technologies and software (Open Source) in view of cost containment, openness and accessibility, even for training purposes. Scatol8® is not only a product, but also an initiative to spread knowledge, by Socials and in presence, which aims to involve young people in the creation of technology (and not only in its use), which is accompanied by information tools on the relationship between observed variables and sustainability and proposes the reuse of components through the concrete realization of the active systems.
- Modularity. The system is constituted from time to time, according to the requirements and specifications of each application.
- Environmental compatibility. All units and processing devices are placed in recycled containers, coming mainly from food and electronics industry, transformed and adapted to their new function, or in containers made of wood (a renewable resource), or even cardboard.

Communication plays a key-role in Scatol8®. It presents a number of problems because there are different subjects to which it is addressed (teachers, students, entrepreneurs of various productive sectors) and the means (website, social networks, brochures, research reports). A multilayer communication is carried out continuously, providing news updates to stimulate reflections and to keep the attention, to arouse curiosity in the potential of the system and to encourage involvement in the project proposals.

The System has been developed by Research projects, dealing with Integrated Management Systems, Life Cycle Analysis, Outdoor monitoring. Researches have had a fall out in Education activities in Primary and secondary School. In University Courses, within the School of Management and Economics, Scatol8® is an integral part of didactics. The e-book “Scatol8®: A Path To Sustainability”, downloadable on http://scatol8.net, can be a useful support in different teaching methods and to different students. It is possibile to prepare tailor-made releases of the book, combining parts of it in relation to teachers and students’ needs.

6. Grass8

Grass8 is the proposal that Scatol8® is developing for the monitoring of pastures, in collaboration with the DISAFA Department of the University of Torino.

6.1 Previous experiences

The idea of dealing with agricultural systems has matured at the beginning as a preparation of a system for domestic plants. Temperature, humidity and brightness. Then evolved to S8 - Ecosystem and Scatol8 Smart Garden.

Each step has added functionality to the Scatol8, to meet the needs of different users: "green thumbs" home; Scatol8 Team interested in exploring the possibility of the system in terms of modularity and expandability; landscape architects, garden builders and green areas.

6.2 Characteristics of the system

Scatol8® will physically build the prototype of the networks and calibrate it in grassland contexts. This will imply extending the range of sensors available, which already determine for example: wind direction distance, snow height, gas (different kinds), light, mass (such as waste production), movement, Oxidation Reduction Potential, pH, rain, air pressure, solar radiation, ultraviolet radiation, soil temperature, air temperature, soil moisture, air humidity, leaf wetness and wind speed. Selection of variables, identification of indicators, choice of sensors and actuators will be done in collaboration with the DISAFA Department of the University of Torino.

Not only the progress in the performance to which we aspire concerns the performance of the network, but also the integration between open access data and those detected by Scatol8®; data processing and representation to feed management systems dedicated to various types of companies, through which to organize operations in the field and measure economic and environmental performance.

7. Conclusions and perspectives

IoT has all the requisites to make agriculture part of the Fourth Industrial Revolution.

IoT will add value if skills in data, Big Data elaboration are available. The IoT trend sends a clear message to the world of university education. It urges the design of new courses that prepare data scientists. The ability to extract useful information from the data, so called data-mining, requires the establishment of multidisciplinary groups. The IoT network works if there is a network of knowledge, oriented towards a shared goal. First of all, users must be involved in a dialogue that makes needs emerge and that, at the same time, is useful to expose the potentialities that the new tools make available, so that we can reach truly useful solutions.

IoT is a business opportunity. The hardware costs are going down and this circumstance supports the predictions of an exponential increase of devices and networks. Software for network operation becomes more accessible. The crucial aspect, we reiterate, lies in the intelligence of the system.

Agriculture will become SMART, thanks to the IoT, when it will avoid man fatigue, when it will be able to close the game with world hunger, winning it, not standardizing production but multiplying the niches of biodiversity.

The challenge that today is possible to face thanks to the IoT is to realize accessible SMART technologies, systems that learn from the human, able to incorporate instructions but thanks to the knowledge distributed in the Internet, to which they can access, and to the new materials / devices improve efficiency and effectiveness of agricultural practices, with a dialogue that involves the entire supply chain.

The challenge of the IoT is not only to improve the efficiency of standardized productions, but to increase the efficiency of the niche markets, which carry forward the wealth deriving from the variety. By these ways we will have enough food for all and gourmand food for few.

There will be greater quantities of standardized mass products, next to which today niche products will be more accessible, deriving from food raw materials grown with less effort and greater productivity. The IoT leads to the growth of companies (micro and small enterprises) able to create customized systems, with a high knowledge content.